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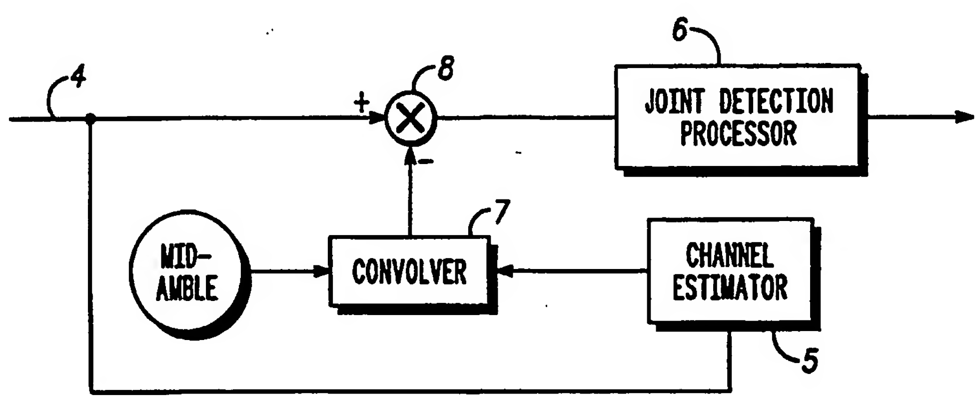

(57) Abstract

A signal processor (7,8) for a telecommunications receiver, and particularly applicable to TD-CDMA systems, provides a means for removing interference from a received data block (2) caused by the multi-path effects of the midamble portion (3) of the received signal. The known midamble sequence (3) is convolved with an estimate of the propagation channel (5) and the result is subtracted (8) from the received signal (4). The corrected signal can then be input to a conventional joint detection processor (6) for further processing.

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A RECEIVER FOR SPREAD SPECTRUM COMMUNICATIONS SIGNALS

This invention relates to radio receivers and particularly to radio receivers for TDMA or TD-CDMA Mobile Communications Systems.

In a TDMA (Time Division Multiple Access) system, a communication channel consists of a time slot in a periodic train of time intervals over the same frequency. Each period of time slots is called a frame. A given signal's energy is confined to one of these time slots. Adjacent channel interference is limited by the use of a time gate or other synchronisation element in the receiver that only passes signal energy received at the proper time.

In contrast to TDMA, a CDMA (Code Division Multiple Access) system allows signals to overlap in both time and frequency. In principle, in a CDMA system the information data stream to be transmitted is impressed upon a much higher rate data stream known as a signature sequence. Typically, the signature sequence data is binary, providing a bit stream. One way to generate this signature sequence is with a pseudo-noise (PN) process that appears random, but can be replicated by an authorised receiver. The information data stream and the high bit rate signature sequence stream are combined by multiplying the two bit streams together, assuming the binary values of the two bit streams are represented by +1 or -1. This combination of the higher bit rate signal with the lower bit rate data stream is called coding or spreading the information data stream signal. Each information data stream or user channel is allocated a unique spreading code.

One CDMA technique "traditional CDMA with direct spreading", uses a signature sequence to represent one bit of information. Receiving the transmitted sequence or its complement (the transmitted binary sequence values) indicates whether the information bit is a 0 or a 1. The signature sequence usually comprises n-bits and each bit is called a "chip". The entire n-chip sequence, or its complement is referred to as a transmitted

symbol. The receiver correlates the received signal with the known signature sequence of its own signature sequence generator to produce a normalised value ranging from -1 to +1. When a large positive correlation results, a 0 is detected. When a large negative correlation results, a 1 is detected.

A plurality of coded information signals modulate a radio frequency carrier, for example, quadrature phase shift keying (QPSK) and are jointly received as a composite signal at a receiver. Each of the coded signals overlaps all of the other coded signals, as well as noise-related signals in both frequency and time. If the receiver is authorised, then the composite signal is correlated with one of the unique codes, and the corresponding information signal can be isolated and decoded.

In a TD-CDMA (Time Division-Code Division Multiple Access) system, each time-slot within the TDMA time frame is divided into a plurality of channels which are uniquely distinguished from each other by means of the CDMA process. The use of such a system gives some advantages over a communications system using either TDMA or CDMA alone.

A TD-CDMA receiver needs to be able to separate the time slots in each frame and also separate the coded signals (by using a correlation process). By such means, channels can be separated at the receiver. If all the unique codes within a time slot are orthogonal, rejection of unwanted channels at the receiver is complete. However, the transmitted composite signal can become corrupted in the transmission process and in such cases, the codes arriving at the receiver are no longer orthogonal. This results in signals from unwanted channels corrupting the data on the wanted channel.

This form of interference can be removed by the known process of "joint detection". In a typical joint detection receiver, the receiver is provided with all the codes and therefore able to decode all the channels within a given time slot. Further processing of the channel outputs enables a better estimate of the wanted channel signal to be obtained. One known method of estimating an unknown transmitted channel symbol sequence in a joint detection receiver involves zero-forcing block-linear equalisation.

The current TD-CDMA proposal for the air interface of the third generation mobile telecommunications systems (UMTS-Universal Mobile Telecommunications Systems) requires that joint detection of multiple codes is performed by the receiving end of the link. This requires that each mobile radio channel from the one (in the case of the downlink) or multiple (in the case of the uplink) transmitters to the receiver must be estimated.

The propagation channel through which a transmitted burst passes, comprises a transmit filter, a mobile radio channel and a receiver filter. The propagation channel is of a fixed length - W chips. A burst typically comprises at least one data block of say, N symbols and a pre-defined training sequence.

Normally, the joint detection equations can be solved using propagation channel estimates and knowledge of the spreading codes used.

The signal model normally assumed is $\underline{r}=\underline{A}\underline{d}$
where r is the received signal vector (of length NQ+W-1 chips) arising due to a symbol block of length N Symbols, where Q is the spreading factor.
$\underline{d}$ is the vector containing the symbol transmitted for each code and
$\underline{A}$ is the modulation matrix containing information regarding the user spreading codes and channel estimates. This is of size (NQ+W-1) NK where K is the number of codes (or user channels).

These equations however as they stand, do not take into account the interference caused by the training sequence portion of the burst due to reflections of the transmitted signal prior to their arrival at the receiver. i.e. multi-path effects are not taken into account. The equations are not representative of the true situation for the last W-1 chips of $\underline{r}$ when processing the first block, nor for the first W-1 chips of $\underline{r}$ when processing the second block. This results in a performance degradation because the joint detection processing does not take the interference caused by the training sequence into account.

This invention aims to remove such interference.

The training sequences, often referred to as midamble sequences, in a typical TD-CDMA mobile communications system are known. Also known are the relevant channel coefficients. By using these two facts, the interference caused by a dispersive propagation channel acting on the midamble can be removed from the datablock portions of the received signal.

Accordingly, the present invention consists of a signal processor for a receiver forming part of a telecommunications system in which an information signal burst transmitted from a remote transmitter and comprising at least one data portion and a training sequence portion is received at an input of the receiver via a propagation channel, said burst being degraded in the transmission process,
wherein the signal processor includes apparatus for removing degradation from the received burst incurred in the transmission process,
said apparatus comprising a convolver for convolving an estimate of the propagation channel characteristics with the training sequence of the received burst to generate a correction signal,
and a subtracter for subtracting the correction signal from the received burst to produce a modified burst signal for further processing.

The further processing can comprise a joint detection processing arrangement.

The signal processor may be incorporated in the receiving circuitry of a base station and/or mobile station of a mobile communications system.

An embodiment of the invention will now be described, by way of example only, with reference to the drawings of which;
Figure 1a and 1b are schematic diagrams showing the structure of a transmitted and received burst, respectively, in a telecommunications system to which the invention is particularly applicable,

Figure 2 is a schematic block diagram of a receiver incorporating apparatus in accordance with the invention.

In Figure 1a, a transmitted TD-CDMA burst comprises a first datablock 1 comprising N data symbols and a second data block 2 comprises N symbols, the first and second datablocks 1,2 being separated by a midamble portion 3 of L chips. By virtue of the CDMA technique previously explained, a single burst comprises information associated with a plurality of communications channels.

A propagation channel through which each burst passes typically comprises a transmit filter (not shown), the air interface and the receiver filter (not shown) and is defined as a having a length of W chips.

Figure 1b shows the received burst in which part of block 1 (length W-1 chips) has shifted into the midamble time slot and part of a midamble 3 (of length W-1 chips) has shifted into the second datablock 2 timeslot. This shifting is due to reflections of the transmitted burst over the air interface being detecting at the receiver (i.e. multi-path effects).

The resulting inter-symbol interference caused by the midamble portion being received during the second block timeslot is removed by the apparatus incorporated in Figure 2.

Referring then to Figure 2, a telecommunications receiver, installed in a base station (not shown) and a mobile station (not shown) of a mobile telecommunications network, for receiving a TD-CDMA burst on line 4 is provided with a channel estimator 5 whose output is connected to a joint detection processor 6 and to a first input of a convolver 7. A second input of the convolver 7 is provided with the known midamble sequence. An output of the convolver 7 is fed into a subtracter 8 which also receives the burst on line 4. The output of the subtracter 8 is fed to a joint detection processor 6.

From the received burst an estimate of the channel characteristics is made in the known manner by the channel estimator 5. This estimate is then convolved in the convolver 7

with the known midamble sequence and the result is subtracted (by the subtracter 8) from the received burst. The resulting signal is input to the joint detection processor 6 for processing in accordance with known techniques. The output of the joint detection 6 comprises estimates of the transmitted symbols for each user channel.

For block 1, the last W-1 chips contain a contribution from the midamble. This contribution is simply the convolution of the first W-1 chips of the midamble with the propagation channel. This convolution is performed in the convolver 7 and the interfering signal is subtracted from the last W -1 chips of $\underline{r}$. Similarly, for block 2, the interference caused by the midamble 3 is simply the convoltion of the last W-1 chips of the midamble sequence with the propagation channel for block 2, this can be subtracted from the first W -1 chips of $\underline{r}$ in order to eliminate the interference caused by the midamble 3.

In this manner, 2x(W-1)/Q (rounded up) symbols in each burst will have increased likelihood of being estimated correctly, thus improving performance through reduced bit error rate, or allowing for reduced transmit power to maintain the same bit error rate as was achieved without this additional processing.

Since the number of symbols that are adversely affected by the midamble increases with the mobile radio channel link (or the transmit/receive filter impulse response duration), so the improvement gain through the use of this method also increases. For long mobile radio channels, e.g. hilly terrain, considerable improvements in performance can be achieved.

Also, on the uplink, mobile users will be received with different relative delays so even if actual channel dispersion is low, it can appear as if a given user has a significant impulse response duration, i.e. the delay must be absorbed by the channel estimation process. Thus the invention improves performance in this situation also.

While this invention is most useful when applied to the TD-CDMA case, it is also applicable to TDMA systems.

CLAIMS

1. A signal processor (7/8) for a receiver forming part of a telecommunications system in which an information signal burst transmitted from a remote transmitter and comprising at least one data portion (2) and a training sequence portion (3) is received at an input of the receiver via a propagation channel, said burst being degraded in the transmission process, wherein the signal processor includes apparatus for removing degradation from the received burst incurred in the transmission process, said apparatus comprising a convolver (7) for convolving an estimate of the propagation channel's characteristics with the training sequence (3) of the received burst to generate a correction signal, and a subtracter (8) for subtracting the correction signal from the received burst to produce a modified burst signal for further processing.

2. In a telecommunications system in which an information signal burst(1, 2, 3) is transmitted from a remote transmitter to a receiver via a propagation channel, said burst comprising at least one data portion (2) and a training sequence portion (3), and wherein said burst suffers degradation in the transmission process,
a method for removing said degradation including the steps of:
receiving the transmitted burst,
in the receiver, convolving an estimate of the propagation channel's characteristics with the training sequence portion to generate a correction signal,
and subtracting the correction signal from the received burst to produce a modified undegraded burst .

FIG.1A

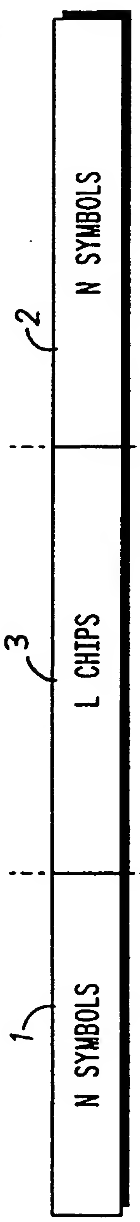


FIG.1B

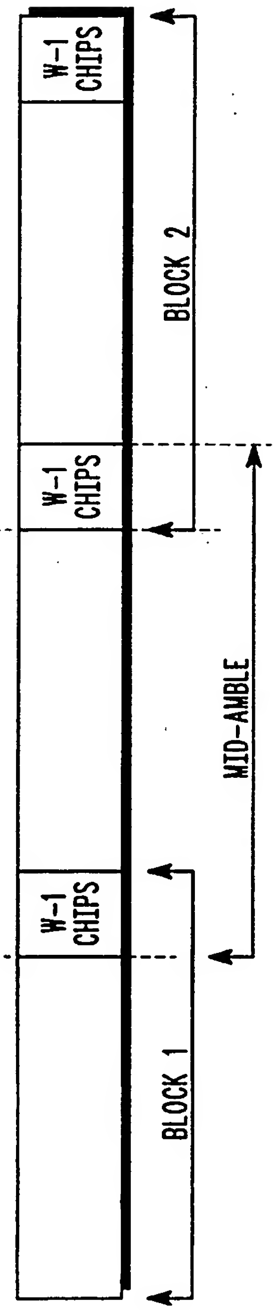
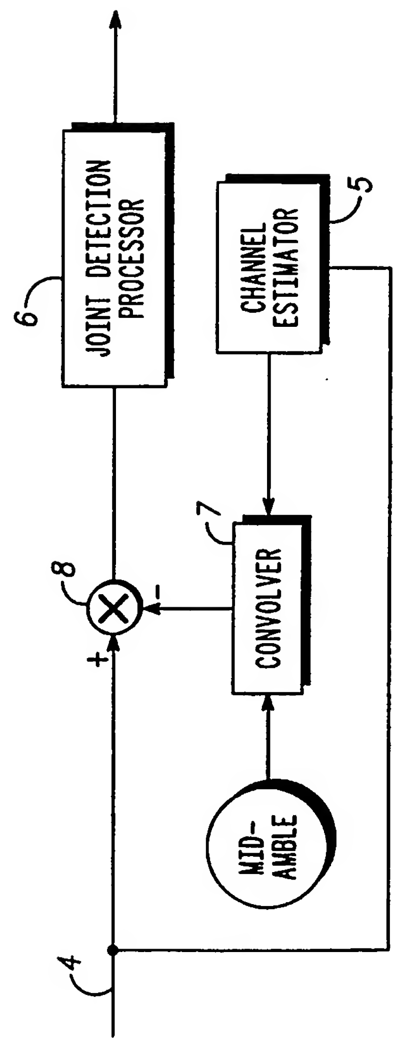


FIG.2



INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04L25/03 H04B1/707 H04B7/005

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04L H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 767 543 A (SIEMENS AG) 9 April 1997 (1997-04-09) abstract page 2, line 21 - line 36 page 3, line 14 - line 24 page 7, line 45 - page 8, line 22 claims 1,2 figures 1,3 ---	1,2
A	WO 98 07243 A (NOKIA TELECOMMUNICATIONS OY ;JOKINEN HARRI (FI); RANTA PEKKA (FI);) 19 February 1998 (1998-02-19) page 2, line 12 - line 33 page 4, line 11 - line 17 figure 2 --- -/--	1,2

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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16 July 1999	26/07/1999

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WO 96 11533 A (NOKIA TELECOMMUNICATIONS OY ;NOKIA MOBILE PHONES LTD (FI); HOTTINE) 18 April 1996 (1996-04-18) page 6, line 27 - line 35 page 17, line 2 - line 23 figures 3,5 -----	1,2

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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CLAIMS

[Claim(s)]
[Claim 1] A frequency converter which carries out the down convert of the carrier signal of predetermined frequency from an antenna at an intermediate frequency signal of predetermined frequency An intermediate frequency amplifier which amplifies said intermediate frequency signal, being controlled so that an output level becomes fixed with automatic-gain-control voltage, and the automatic-gain-control voltage generation section which amplifies an output signal of said intermediate frequency amplifier, direct-current-izes a said-amplified signal and generates said automatic-gain-control voltage It is the radio-signal receiving set equipped with the above, and is characterized by coming to have at least two receiving antennas, a change over circuit which switches said receiving antenna, and an antenna setting-out means to set up said change over circuit so that one more than necessary receiving level of receiving antennas may be chosen based on said automatic-gain-control voltage.
[Claim 2] Said automatic-gain-control voltage based on an input signal by antenna of the present setting out of said antenna setting-out means, A comparator which outputs a suitable signal when reference voltage of setting out is compared and this automatic-gain-control voltage exceeds this reference voltage, When there is an input of said suitable signal from said comparator, an antenna is maintained in the present setting-out location. A radio-signal receiving set according to claim 1 characterized by coming to constitute from a change over control section which controls said change over circuit to switch to an antenna into which said suitable signal is inputted when there is no input of said suitable signal.
[Claim 3] A level detecting element to which said antenna setting-out means detects level of said automatic-gain-control voltage for every receiving antenna, The memory section which a disregard level from said level detecting element is made to correspond with a receiving antenna, and memorizes it, The distinction section which distinguishes the maximum level of the disregard levels which said memory section comes to memorize, After having controlled said change over circuit, a level detecting element, the memory section, and the distinction section, switching said change over circuit one by one and making said level detection make, A radio-signal receiving set according to claim 1 characterized by coming to constitute from a change over control section which controls said change over circuit to set it as a receiving antenna of said maximum level which said distinction section distinguished.
[Claim 4] The radio-signal receiving set according to claim 3 characterized by to control said change over circuit by said change over control section based on distinction of the maximum level by said distinction section based on stored data which prepares the timer section which makes time-amount measurement in the bottom of said change over control section, and is applied to renewal of stored data of said memory section based on level detection by said timer section according to said level detecting element the whole predetermined passage of time, and this level detection, and renewal of said, and this distinction.

[Translation done.]